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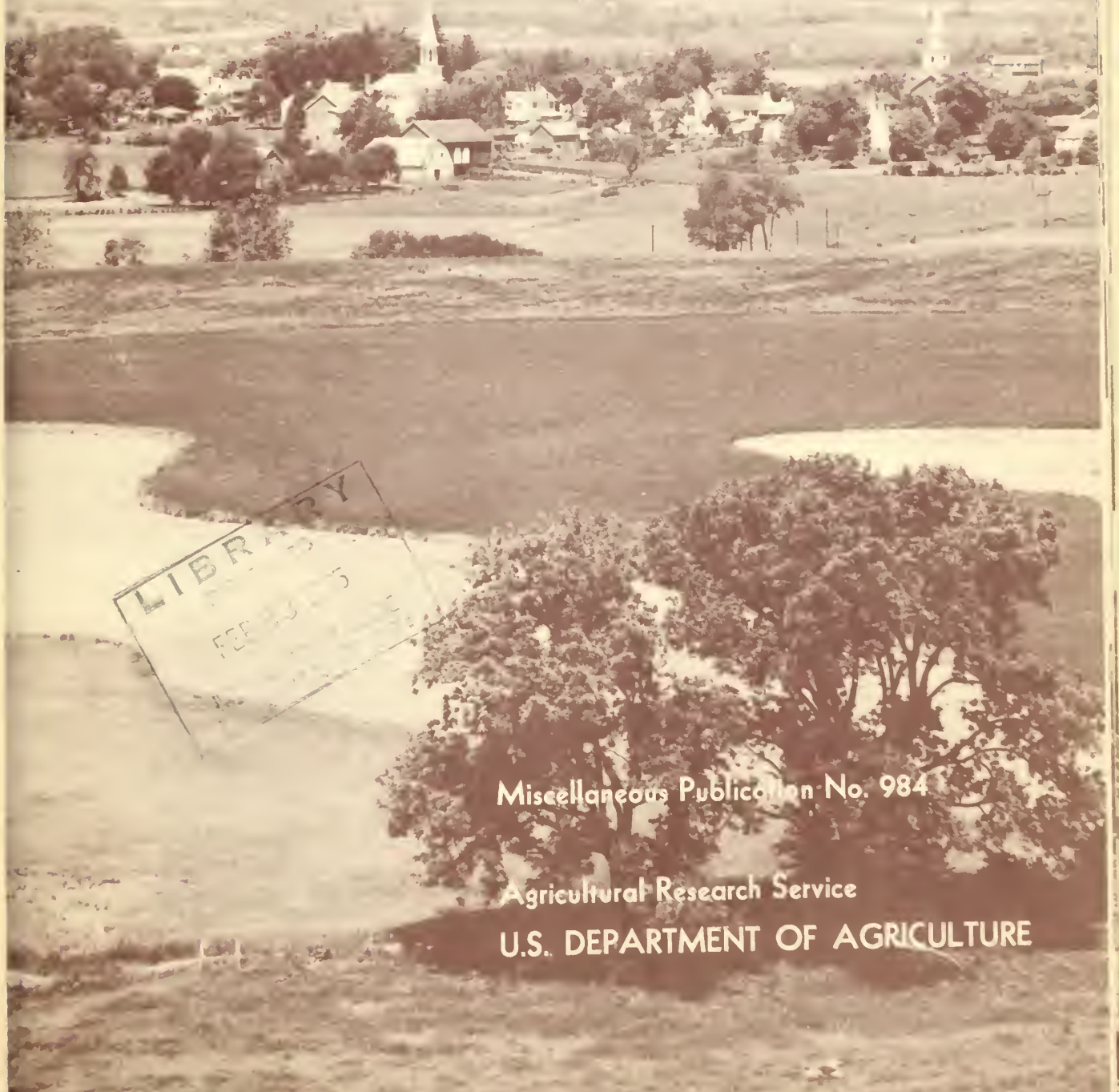
SOIL AND WATER CONSERVATION RESEARCH in the Northeastern States



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Agricultural Research Service

U.S. DEPARTMENT OF AGRICULTURE

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▶Strip cropping conserves soil and water in the Frederick Soil Conservation District (Maryland).

Washington, D.C.

Issued January 1965

Soil, Water, and the Conservation Team

Soil and water are the Nation's two most vital natural resources. Orderly and wise development and conservation of these resources depend on the efforts and interests of many groups. Collectively, these groups are the *Soil and Water Conservation Team.* This team includes farmers, ranchers, Soil Conservation District personnel, technicians, teachers, extension workers, economists, and research workers.

To be effective, teamwork must reflect a background of sound technical information; research has provided this pool of knowledge. Practices now being applied represent the results gleaned from many years of experience.

But we need to know more. Our expanding population and the consequent demands for more food and fiber have created new problems in the management and use of soil and water. Facts gained from research today will provide the bases for conserving soil and water tomorrow.

. . . FARMLAND IS BEING COVERED WITH HOUSES . . .

. . . AND FACTORIES.

SOIL AND WATER CONSERVATION RESEARCH

in the Northeastern States

Prepared by Clarence S. Britt, Soil Scientist, Soil and Water Conservation Research Division
Agricultural Research Service

The Northeast Branch of the Soil and Water Conservation Research Division conducts research in cooperation with nine Agricultural experiment stations in the Northeastern States. In addition, specialized research is conducted by four national laboratories—the U.S. Fertilizer Laboratory, the U.S. Hydrograph Laboratory, and the U.S. Soils Laboratory at Beltsville, Md., and the U.S. Plant, Soil, and Nutrition Laboratory at Ithaca, N.Y.

The fine cooperation of State agricultural experiment stations, related Federal agencies, and private industry contributes greatly to continuing progress in soil and water conservation research.

State agricultural experiment stations in Maryland, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Vermont, Virginia, and West Virginia actively participate in research activities with the Branch through consultation in scientific matters and by providing research personnel and facilities.

Some of the research is cooperative with Crops Research and Agricultural Engineering Research Divisions of the Agricultural Research Service and with the Soil Conservation Service. Other Federal cooperators include the U.S. Army Corps of Engineers and the U.S. Weather Bureau.

Private industries making notable contributions to the research include manufacturers of farm machinery, plastics, and fertilizer.

The Northeast, though heavily populated and highly industrialized, produces large quantities of perishable food crops, milk, and poultry products. Urban and industrial development and highway construction are expanding rapidly—often at the expense of the best agricultural land. The demands on soil and water resources are continually increasing. Although water supplies currently are adequate during most of the year, there are frequent periods of moderate drought and occasional periods of severe drought when water supplies become critical both on the farm and in the city.

Farming in much of the area has been intensive because of the ready market and favorable climatic conditions. Perishable food crops and dairy and poultry products have been produced in abundance. Farm income in 1960 was estimated to be 3,904 million dollars for the 13 Northeastern States, or about 11 percent of the total for the United States.

Since more people are living on less land in the Northeastern United States than in any other part of the country, this food production is all the more remarkable. Much farmland is being covered with houses. The 1960 census showed about 230 persons per square mile of land area in the Northeast compared with the national average of 60 persons per square mile. In the United States, only four States—Connecticut, Massachusetts, New Jersey, and Rhode Island—have population densities greater than 500 persons per square mile. The 13 Northeastern States, with only 6.6 percent of the land area, contain 31.3 percent of the people.

As population increases, conservation and wise use of soil and water resources become increasingly important. Landowners and the public alike are interested in conservation measures that will make the development of soil and water resources more permanent. Increasing our technical knowledge through soil and water research will insure getting the best possible conservation job done with the least cost.

SEDIMENTATION RESEARCH

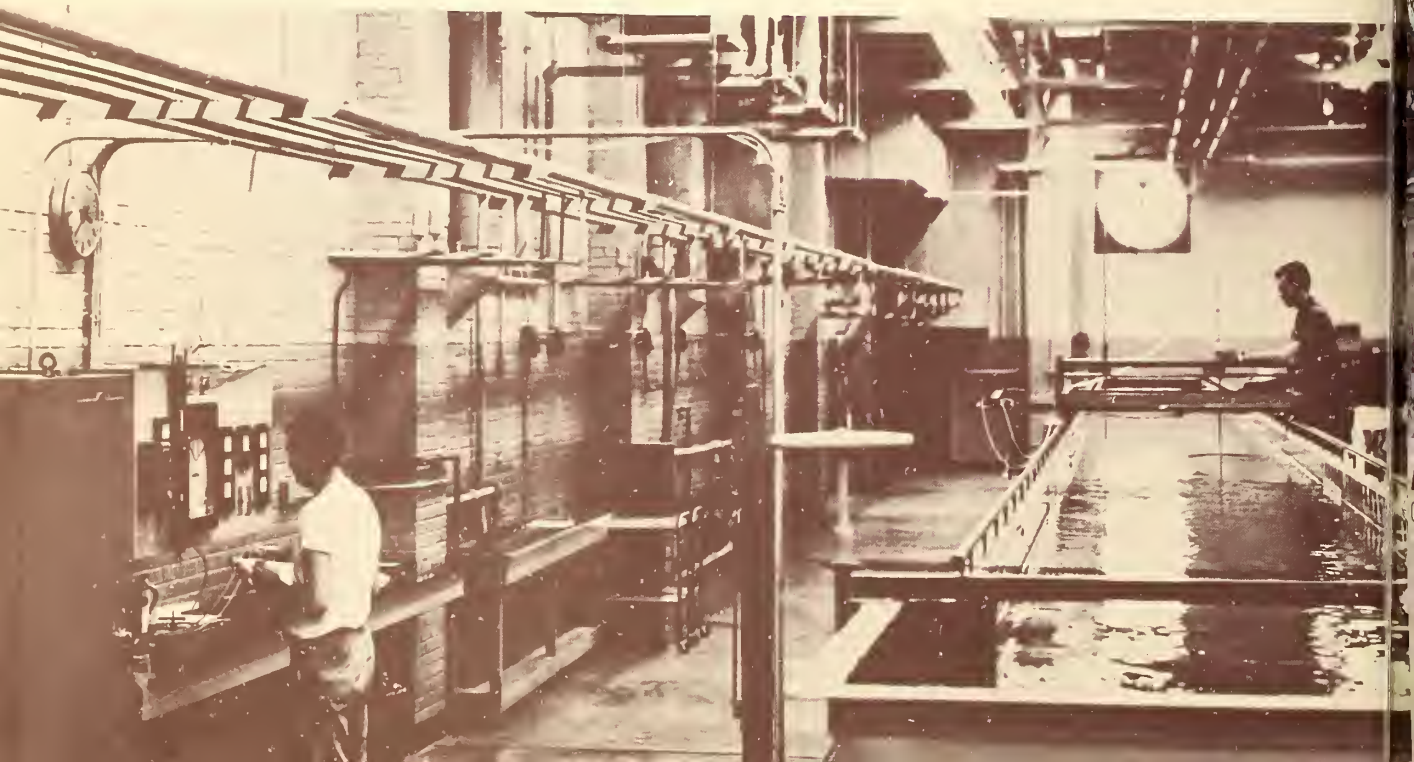
Sedimentation research provides information on problems caused by silting of road ditches, irrigation and drainage ditches, streams, harbors, and reservoirs and by harmful deposition on agricultural lands. The pollution of waters with silt spoils recreation sites, is harmful to fish and wildlife, and increases the cost of filtering water for human uses.

Research seeks information on--

- Sediment sources and yields from agricultural watersheds.
- Rates and processes of reservoir silting.
- Mechanics of sediment origin, transportation, and deposition.
- Streambank erosion processes.
- Measures for stream channel stabilization.

▲This sediment blocks the route to a school at Bethesda, Md. Other sediment may end up deposited in a reservoir or lake.

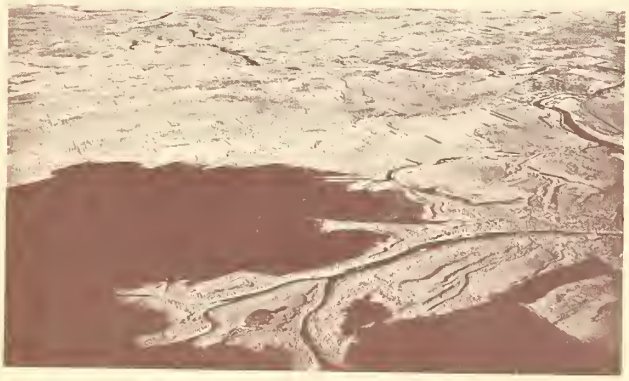
▼Research in the Northeast Branch is coordinated with that of the U.S. Department of Agriculture's Sedimentation Laboratory located at Oxford, Miss., which serves as the national center for sedimentation research.



▲Where does sediment come from? The bank eroding beneath this barn in the Chautauqua Soil Conservation District (New York) is more than 12 feet high.

▲Unprotected farmland in the Anne Arundel Soil Conservation District (Maryland).

▼Improper planning in this housing development is causing severe erosion in the same Soil Conservation District. Sediment from these two areas fills normal drainage channels and roadside ditches in addition to silting and polluting the waters of the Patuxent River.



▲Extensive sediment deposits along banks of Patuxent River. Silt from areas above has polluted the stream and has been detrimental to fish and wildlife. Because of its proximity to metropolitan areas, this river is an important source of water. It should also be developed for recreation. Full use will be possible when sediment is controlled at its sources.

◀Delta in foreground was formed by silt from Missisquoi watershed in Vermont. This is in Missisquoi Bay on Lake Champlain. An estimated 98,890,000 acre-feet of sediment is deposited in the Nation's reservoirs each year. This amount of sediment fills storage capacity sufficient to irrigate 2,250,000 acres of land or to provide a year's water supply for 50,000,000 people.

◀Riprap being installed on the banks of Buffalo Creek, N.Y., by the Soil Conservation Service to resist and dissipate the energy of flowing water around the bend. Research on this complicated problem tells where around the bend to place the stones, and how large they need to be to withstand the forces exerted by flood waters.

◀This riprap on Buffalo Creek has withstood flood conditions. Note large debris deposited on upper bank by flood. Measurements on the stream have shown that sediment entering Buffalo Harbor has been reduced 40 percent by these and other streambank erosion control measures.

HYDROLOGIC RESEARCH

Hydrologic research studies water resources as related to agricultural watersheds. A major purpose of hydrologic research is to provide information to the Soil Conservation Service for its action program on upstream watersheds. Because projects must justify their costs, we need to know how often floods occur, how large they are, and what control measures are needed. As water becomes more important, we need to know how much dependable water is available for irrigation, recreation, and municipal use, and whether or not we can manage watersheds to increase water supply or make it more dependable.

Research to provide answers that will offer the most economical solution to these and similar problems covers—

- Precipitation patterns.
- Soil-moisture accretion and depletion.
- Ground-water accretion, movement, and basin recharge.
- Aquifer streamflow relations.
- Water yield and water supply and quality.
- Floodflows and storm runoff.
- Criteria for watershed protection.

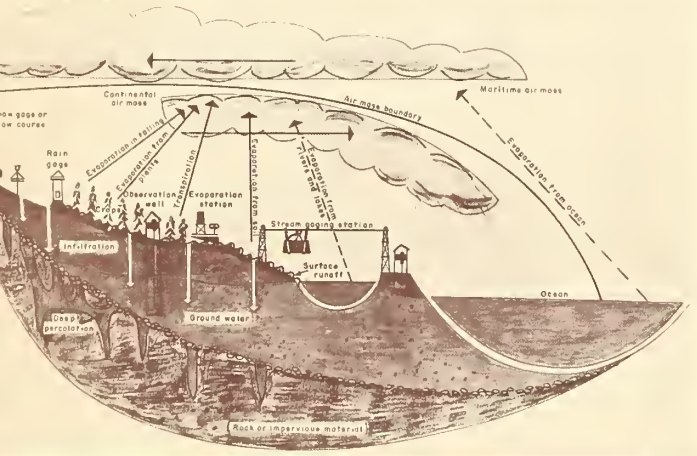
▲Flood in Pocomoke River in the Coastal Plain area of Maryland's Eastern Shore. Little is known of the hydrology of these very flat areas. Research in hydrology is a long-time process if it is to adequately evaluate variable weather cycles.

▲This dam in the Garrett Soil Conservation District (Maryland) was designed by the Soil Conservation Service on the basis of hydrologic knowledge developed through research. Some risk of failure—or of expensive overdesign—must be taken because research information is limited. Research provides increased knowledge that will permit us to reduce the risk and obtain the most economical installation.

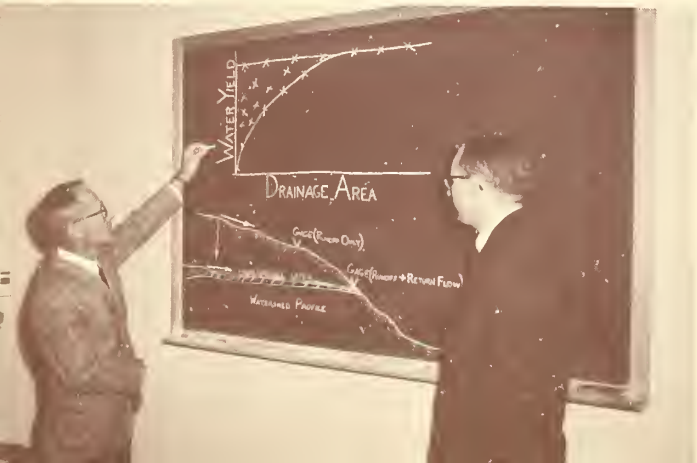
▼Flood damage caused by Cady Brook in Massachusetts. Such damage can be reduced when more research information is available on upstream watersheds.

◀Snow provides much of the water in the Northeast. Research on the Sleepers River Experimental Watershed near Danville, Vt., will help predict water yields and flood flows.

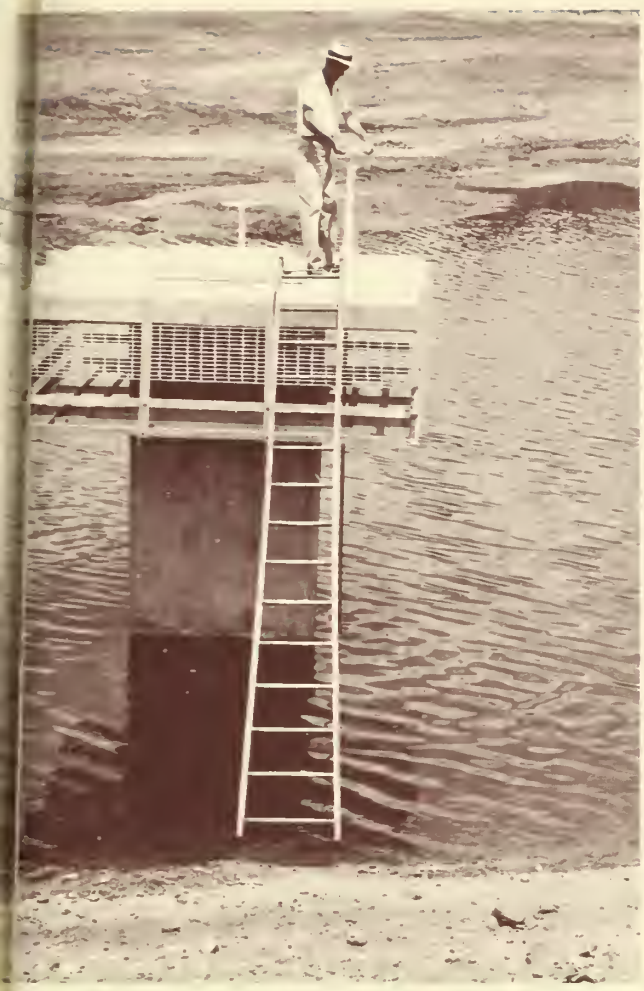
◀Stream gaging station on Sleepers River gives research information on flood flows and water yields from steep mountain streams. Hydrologic information will be related to snow and rainfall patterns, farmland use, and water infiltration and movement.



◀Hydrologic research aims to describe, explain, and predict the circulation of water in the hydrologic cycle. Several Federal, State, and private agencies are involved in this total effort, each concentrating on one or more phases. The Soil and Water Conservation Research Division, whose responsibility is in the land phase, concentrates primarily on precipitation patterns, evaporation and transpiration, infiltration, ground water, and surface runoff.



◀As of January 1, 1965, the Soil Conservation Service had received slightly more than 2,200 applications for water-control projects in upstream watersheds; about one-half have been authorized for planning. The U.S. Hydrograph Laboratory works closely with SCS in developing theory and techniques for using high-speed computers for the complex computations to optimize protection programs on upstream watersheds over the Nation. The Laboratory Director and an engineer are shown discussing some of the many problems that must be considered.

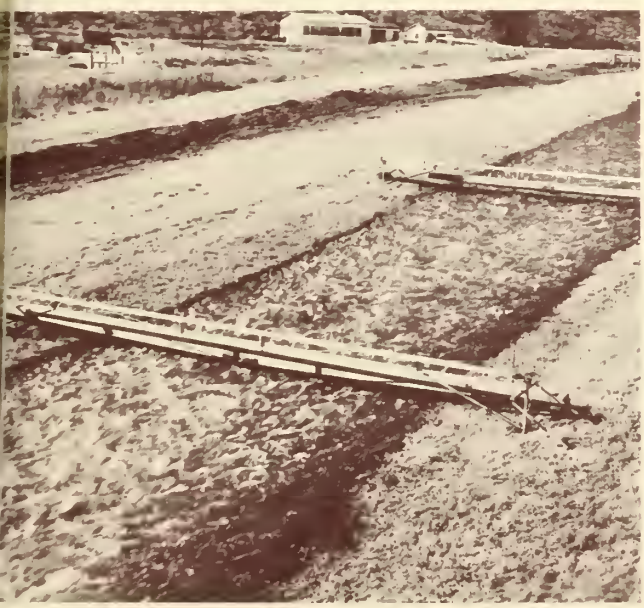


HYDRAULIC RESEARCH

Hydraulic research provides for more economical and safer design of spillways, silting basins, drop structures, flumes, weirs, gates, and vegetative-lined channels. Although the basic hydraulic research is done in other areas, the findings are used in the Northeast by Soil Conservation Service to design watershed-protection structures and other conservation engineering measures, including drainage and irrigation. Research in this area includes—

- Basic studies of hydraulic phenomena.
- Criteria for design of water-control structures.
- Hydraulics of waterways and vegetated channels.
- Flow measurements and water-metering devices.

◀This drop-inlet spillway riser in a floodwater-retarding reservoir was designed according to research information.



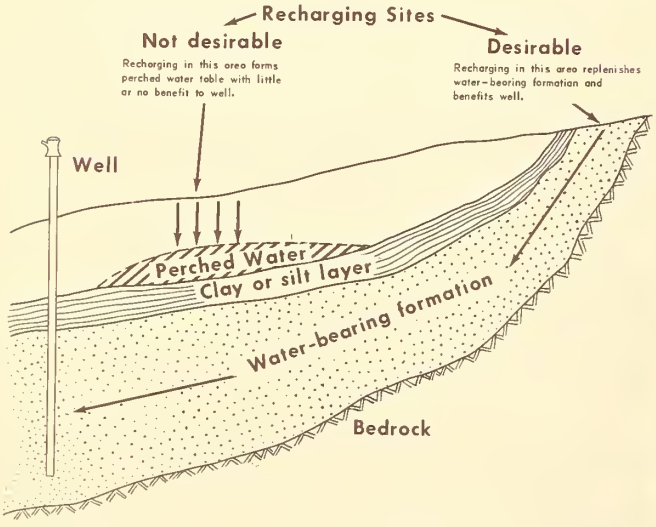
▲Grassed waterway under test at Hydraulic Laboratory, Stillwater, Okla. These and other tests provide information on waterway design, and grass covers to give the most effective protection.

▼Grassed waterway designed by Soil Conservation Service using research information.

CONSERVATION OF WATER SUPPLIES

Conservation of water supplies for agricultural use is becoming more important in the Northeastern States. Use of water on farms is increasing rapidly. At the same time, municipal and industrial water requirements are expanding and competing for existing supplies. Much of the research centered at the U.S. Water Conservation Laboratory, Tempe, Ariz., and seven other field stations will be of interest in the Northeast. This work includes—

- Control of seepage from farm ponds.
- Evaporation from water, soil, and plant surfaces.
- Ground-water recharge.
- Water-measuring devices.
- Basic studies of evapotranspiration relations.
- Precipitation storage and collection systems.


Recharging Sites
Not desirable
Recharging in this area forms perched water table with little or no benefit to well.
Desirable
Recharging in this area replenishes water-bearing formation and benefits well.
Well
Perched Water
Clay or silt layer
Water-bearing formation
Bedrock

▲Ground-water recharge studies in the Western States will give much information of value in the East. The selection of a recharging site depends on underground formation. Recharged water that reaches the water-bearing strata will benefit the wells and will not be subject to evaporation.

▲Shallow ground-water development in the Coastal Plain area of Virginia provides water for irrigation of vegetable crops. Research information is necessary for adequate design of these pits.

◀Dry pond being lined with plastic to reduce seepage. New low-cost chemical treatments under test may provide control of seepage at less cost than present methods.

▼Pond after lining with 8-mil vinyl liner at a cost of about 30 cents per square yard. Three ponds have been lined in Virginia to test seepage control under different conditions.

◀More accurate estimates of water losses from soil and plant surfaces are possible because of recent developments. Plastic sealed around plants to act as a vapor barrier can eliminate evaporation from soil surface.

▼Neutron soil-moisture probe gives dependable measurement of water in soil at different depths. Surface unit on right has been disconnected.

IRRIGATION RESEARCH

Irrigation research in the Northeastern States is designed to provide data on optimum use of water as supplies become more critical. Efficient use of water on farms will be an important factor in conserving existing water supplies. A comprehensive irrigation research program should include studies of—

- Water requirements throughout the season for different crops.
- Water intake, transmission, and storage for different soils.
- Crop responses to water and fertilizer applications.
- How to make most efficient use of limited supplies of irrigation water.
- Hydraulics of surface irrigation, including row grades and ditch lengths for different soils.
- Sprinkler distribution patterns and test procedures.
- Automatic application structures and systems.

◀Studies in New Jersey have given much information on water use by different crops at different growth stages. This basic information will enable the engineer to determine how much water the irrigation system must supply.

Aerial view shows plot layout to study crop response to irrigation and nutrient applications.

▶Water use by cabbage is being measured in this field. Lysimeters in cabbage field are watered and weighed periodically to give evapotranspiration rates that can be used to improve water-use prediction methods. (Weighing device and covers have been moved to grass in front of cabbage field for this picture.)

▲Water use by plants is related to detailed weather records. In addition to improving water-use prediction methods, weather records are studied to help determine best indicators of when to apply irrigation water.

▶Data on water-storage capacities for different soils are needed in water-use studies for setting up bookkeeping systems to tell when to start irrigation. Here, water-retention curves are being determined.

▼Truck crops being irrigated in New Jersey. Research information helps farmers get efficient use of water and grow better crops.

BRACKISH WATER RESEARCH

Extensive areas along the eastern seacoast can be irrigated by brackish water. Brackish water research has made rapid strides in the East, because of excellent basic research done by U.S. Salinity Laboratory in California. Research at Norfolk, Va., covers—

- Sources of brackish water.
- How salts are accumulated and removed from soil.
- How salt accumulation affects soil.
- Salt effect on plants and tolerance of different plants to salt.

▲Pumping brackish water direct from Albemarle Sound for cauliflower irrigation.

▲Some crops are much more tolerant to salt water than others. Tolerance to salt is also related to crop age. All factors eventually will be coordinated to give a safe program for irrigation with brackish water. Cauliflower, without irrigation, produced no crop (top). Cauliflower produced good crop after one irrigation with brackish water (bottom).

Well-drained soils are necessary for brackish water irrigation, so that salts can leach out over winter.

▶At Exmore, Va., salt concentration of soil in foreground where beans are damaged is 6 times greater than that of soil in the background where bean growth is good. Research tests at Norfolk have shown that green beans, radishes, and celery are sensitive crops that will not tolerate high salinity. Crops more tolerant of saline conditions, such as beets, kale, tomatoes, broccoli, squash, cauliflower, or cucumbers, would have been appropriate crops under these conditions. A soil test before planting would have avoided this crop failure.

DRAINAGE RESEARCH

The Northern Coastal Plain and many upland hilly areas have soils that are difficult to farm because of excess water. Improved and less-expensive drainage systems will be possible with research information on the following—

- Surface drainage by landforming and ditching.
- New subsurface drainage materials, including plastic mole-drain liners and filter materials.
- Subsurface drainage installation techniques and equipment.
- Interceptor drains.
- Drainage requirements of crops.
- Hydraulics of drain systems.
- Chemical and biological clogging of tile.

▲Excess moisture can delay spring work.

Excess water standing on surface needs to be removed quickly. Landforming to give a smooth surface is an important part of any drainage system. Research determines adaptability of different soils to land smoothing.

▲The Soil Conservation Service used research information in setting up this field trial in Delaware. Parallel ditches give drainage in spring and are later filled with water for use in irrigating blueberries and other farm crops.

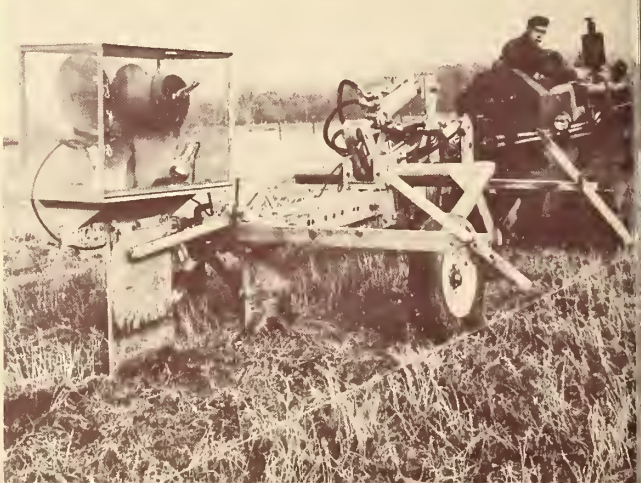
▲Present methods of installing tile are expensive.

▼ Drainage studies on Cabot soil in Vermont are comparing efficiency of surface and subsurface drainage methods used in correcting wet conditions. Water movement in soil is followed by pipes or piezometers driven to different depths in soil. Small meter shown here gives accurate measurement of water height in piezometers. Research results and improved research procedures will help drainage programs on other soils.

▼Mole plow used for installing experimental plastic liner. The liner here is 15-mil perforated semirigid vinyl plastic sheeting on spool shown on top of plow. The die-cut edges are "zipped up" as plastic sheet is formed into channel liner.

Research in New York in cooperation with Cornell University, Caterpillar Tractor Company, and Union Carbide Plastics developed methods for lining mole channels with plastic. This offers promise of making mole drainage effective over a wide range of soils. Many experimental installations have been made.

Methods and principles of mole-channel lining are being further developed and improved in cooperation with the Ohio Agricultural Experiment Station. Chief advantages of mole-line drains are rapid installation and low initial cost.



WATER AND WIND EROSION RESEARCH

The control of water and wind erosion on cropland is still one of the most important jobs in the conservation program on farms. Considerable progress has been made in applying control measures, but these programs will be improved by basic and applied research on—

- Physical processes of wind and water erosion.
- The effect of climatic factors—wind, rainfall, freezing, and thawing.
- The effect of topography—length, steepness, curvature, and exposure of slopes.
- Soil and rock characteristics in relation to erosion.
- The effects of soil and crop management practices.
- Development of improved practices for control of runoff and erosion.
- Development of better erosion-prediction methods.
- Soil-loss tolerance rates.

▶Engineering studies at Durham, N.H., developed the drop formers presently used in the laboratory rainfall simulator in Maine. Many measurements were necessary to get drop size and energy of impact similar to that of natural rainfall.

Present studies in Maine are dealing with methods of using the rainfall simulator to classify soils according to erodibility.

▼Runoff and soil-loss measurements on potato plots at Presque Isle, Maine., will help in determining factors causing erosion and also in the development of prediction methods and improved practices for controlling erosion.

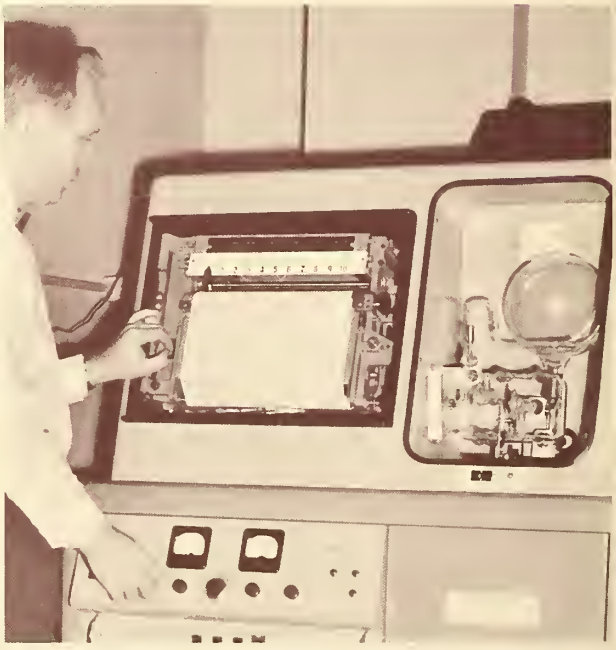
Plot results will also be useful in calibrating the rainfall simulator at Orono, Maine. Following calibration, this simulator will be used to evaluate the soil-erodibility factor to be used in the Universal Soil-Loss Equation.

▲Contour strips such as these are difficult to farm because of many irregularities. Studies in Virginia are using land smoothing or forming as a means of better adapting conservation measures to modern farming. Management practices that will restore subsoils exposed by landforming are of particular interest to soil conservationists in most areas of the Northeast.

SOIL MANAGEMENT RESEARCH

Research on soil properties, processes, and management in relation to the conservation and efficient use of land and water resources involves—

- Fundamental factors concerned with soil-structure formation.
- Tillage methods and cropping systems.
- Chemical reactions and availability of nutrients in soils.
- Nutrient requirements and mechanism of nutrient uptake by plants.
- Biological reactions in decomposing crop residues.
- Chemistry of reactions and persistence of pesticides in soils.
- Minimizing potential hazards from radioactive fallout in soils and plants.



▲Loss of nitrogen applied to soil can be more than 35 percent. With 3 million tons of nitrogen applied to soil, this loss represents several million dollars each year. The mass spectrometer and radioactive nitrogen (N^{15}) are tools used by scientists to determine how much of the nitrogen is recovered by the plant.

▲Research results mean better grass and legume pastures throughout the region.

▲Carefully controlled experiments on grasses and legumes are conducted in cooperation with U.S. Regional Pasture Research Laboratory, University Park, Pa.

▶Corn grown with no tillage shows unusual promise in Virginia and New York. Herbicides are used to kill the old sod and to control weeds. Excellent yields have been obtained over a 3-year period. The grass sod provides a mulch that conserves soil and water.

◀The roots of good sod help soil structure.

▲Net radiometer in corn field gives information on energy available for plant growth, evapotranspiration, and heating the soil.

SOIL, WATER, AND PLANT RELATIONS RESEARCH

Research on soil-water-plant relations is giving basic information that will lead to more efficient use of water resources by crops. Studies include—

- Factors influencing the entry of water into plant roots.
- Soil processes that influence diffusion and flow of substances to plant roots.
- Meteorologic processes that influence the exchange of water and carbon dioxide between plants and the atmosphere.
- Crop management practices for maximum energy conversion.

▶Climatic factors that affect the growth and water use by corn plants are being measured. Studies of complex biophysical processes are giving better understanding of the secrets of plant growth and water-use efficiency.

NUTRITION OF ANIMALS AS AFFECTED BY SOILS AND PLANTS

▲Areas in the United States where mineral nutritional diseases of animals have been known. The dots indicate approximate locations where troubles occur. Lines not terminating in dots indicate a generalized area.

The U.S. Plant, Soil, and Nutrition Laboratory at Ithaca, N.Y., is studying nutrition of animals as affected by properties and characteristics of soils and plants. The studies involve—

- Interrelations among copper, sulfur, and molybdenum in animal nutrition.
- Role of manganese in bone formation.
- Relation of trace elements, especially selenium, in soils and plants to the geographic distribution of white muscle disease (muscular dystrophy) in lambs and calves.
- Identification of soil regions and soil types associated with nutrient deficiencies and toxicities.
- Chemistry of trace elements in soils affecting their availability to plants.
- Metabolism of sulfur in plants with special emphasis on the factors influencing the content of the essential sulfur-containing amino acids in plants.
- Pathways followed by nitrogen from the inorganic forms to the formation of plant proteins.
- Key steps in the process of protein synthesis.

▼Sampling forage crops for chemical analyses to discover relation between trace element content of plants and muscular dystrophy in lambs and calves.

▶A lamb suffering from white muscle disease. This disease in livestock is distributed in a geographic pattern that suggests that soil and plant composition factors may be associated with its occurrence.

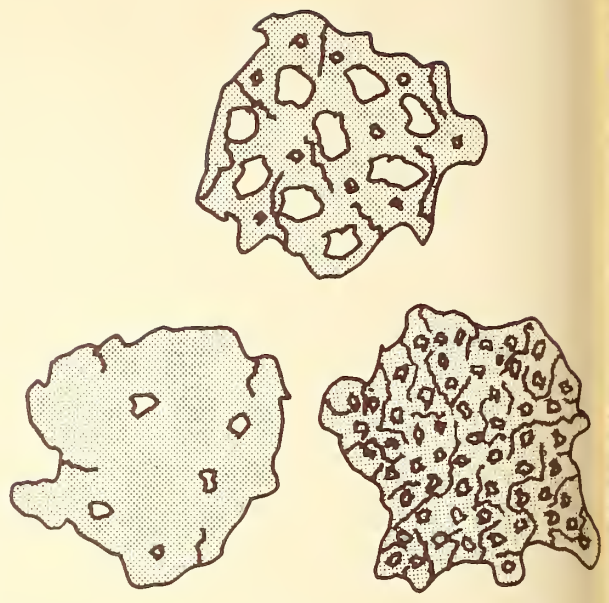
A better understanding of the complicated mechanism involved in nutrition will serve as a basis for improvements in animal feeding practices.

FERTILIZER TECHNOLOGY INVESTIGATIONS

Fertilizer technology investigations covering resources, production, and improvement have played an important part in maintaining fertilizer prices at a steady level during recent years while other farm costs have increased significantly. Research by the U.S. Fertilizer Laboratory at Beltsville, Md., has been cooperative with other Government agencies and with the fertilizer industry. The research covers—

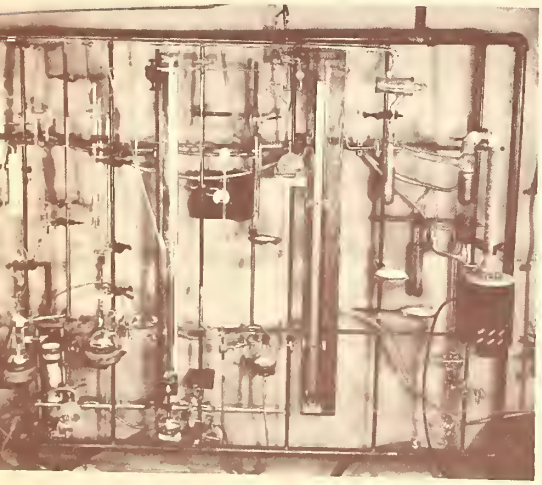
- Materials development and refinement.
- Mixed-fertilizer investigations.
- Quality-control methods for marketed products.
- Agricultural chemical additives.
- Consumption trends and fertilizer-use patterns.

Phosphate rock used in fertilizer manufacture is mined in a number of locations throughout the world. Rock from each deposit has a characteristic physical structure and chemical composition. Recent studies show that extent and size of pores are important in determining rate and degree of reaction of the material in fertilizer manufacture.

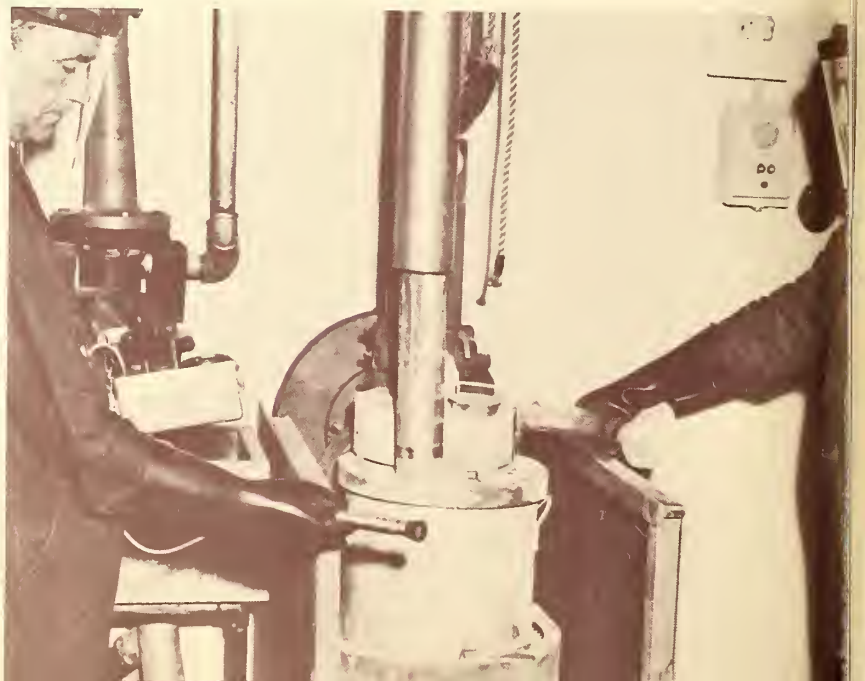


▲Cross sections of phosphate rock particles magnified about 3,000 times. The most desirable rocks have a porous structure and a high proportion of pores finer than 0.06 micron (two millionths of an inch) in diameter.

▼Equipment used to measure the volume of pores in phosphate rock.



▼Manufacture and synthesis of fertilizer materials tagged with radioactive elements have helped increase understanding of fertilizer uptake and use by plants.



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